

some parts. When a child is born, the husband goes to bed for thirty days, and the wife looks after the work. At the conclusion of the paper, Lord Northbrook and Col. Yule paid a well deserved tribute to the late Capt. Gill, Prof. Palmer, and Lieut. Charrington. Capt. Gill, our readers may remember, had himself done some first-rate work on the South-East Chinese frontier, and described it in his "River of Golden Sand;" while Prof. Palmer's loss as an Arabic scholar is almost irretrievable.

SAMOYEVES report to Archangel that they have recently seen, south of Waigatz Island, the wreck of a large vessel crushed in the ice. If the statement be true, and if we remember their never-credited story of the unfortunate *Jeannette*, it is more than probable that the vessel is either the Danish exploring vessel the *Dijmphna*, with Lieut. Hovgaard's expedition, or the Norwegian steamer *Warna* with the Dutch meteorological expedition, bound for Port Dickson, both of which in September last froze in the Kara Sea, from which place the ice may subsequently have carried the unfortunate vessel to where she now is stated to be. The last intelligence received from Lieut. Hovgaard was dated September 22, and addressed to Herr Aug. Gamil, of Copenhagen, the principal promoter of the expedition, from which it appears that all was then well with both vessels, but that the *Dijmphna* was, when caught in the ice, some considerable distance from shore, in fact in a spot where the whole force of the polar ice, when in drift, would strike her. Herr Aug. Gamil having telegraphed to the Russian Admiralty for any confirmation of the above report, has received a reply that no official information on the subject has been received at St. Petersburg; but that nevertheless instructions would be at once given to the officials on the north coast to scour the same, and gather further particulars. A search party is also being contemplated in Copenhagen, which will, if decided on, be led by M. Larsen, a Dane, who accompanied the American expedition in search of the crew of the *Jeannette*, as the special artist of the *Illustrated London News*.

THE German Government has raised the fund for the scientific exploration of Central Africa and other countries, which in 1882-83 was fixed at 75,000 marks (3750*l.*) to 100,000 marks (5000*l.*) for the financial year 1883-84.

## THE AIMS AND METHOD OF GEOLOGICAL INQUIRY<sup>1</sup>

### II.

IT will be observed that the results obtained by geologists could not have been arrived at had they confined themselves solely to the detection of resemblances and correspondences between the phenomena of the present and the past. The natural forces have always been the same in kind, if not in degree, and we can often watch the gradual development by their means of products which more or less closely resemble the rocks of our sections. But experimental evidence of this kind takes us only a short way, and we are sooner or later confronted by appearances, which are not reproduced by nature before our eyes. As another example of this I shall adduce one which, although it has far-reaching issues, has yet the merit of being readily comprehended without much preliminary geological knowledge. It is moreover instructive as showing how the imaginative faculty works in a mind trained to clear and steady observation of nature. The fact that a large proportion of the lakes of the world rest in rocky hollows or basins had been long known before it occurred to any one to ask how such rocky hollows had come into existence. The question was first asked and the answer given by Prof. (now Sir) A. C. Ramsay. He had pondered over the problem for years before its solution dawned upon him. None of the ordinary agents of geological change seemed capable of producing the phenomena. The most common of all denuding agents—water—certainly could not do so, for although it may dig long and deep trenches through rocks, water could not scoop out a basin like that occupied by Loch Lomond, or any of our Highland lakes. The tendency of water is, on the contrary, to silt up and to drain such hollows, by deepening the points of exit at their lower ends. Did the hollows in question occupy areas of depression—had

they, in short, been formed by unequal subsidences of the ground? Some considerable inland seas, as for example the Dead Sea, and doubtless many larger and smaller sheets of water, owe their origin to local movements of this kind. But it is incredible that all the numerous lakes and lakelets of Northern Alpine regions could have originated in this way. In many cases these lakes are so abundant that it is hard to say of some countries, such as Finland, and large parts of Sweden, and even of our own islands, whether it is land or water that predominates. If all these numerous and closely aggregated rock-basins represent so many local subsidences, then the hard rocks in which most of them appear must have been at the time of their formation in a condition hardly less yielding than dough or putty. It was suggested that the lakes of the Alps and other hilly regions might have been caused, not by local sinkings confined to the valleys themselves, but by a general depression of the central high-grounds and water-sheds. The subsidence of the central mountains would of course entail depression in the upper reaches of the mountain-valleys, and in this way the inclination of those valleys would be reversed—each being converted into an elongated rock-basin. But a little consideration showed that before the lakes of such a region as the Alps could have been produced in this manner, those mountains must have been some 15,000 feet higher than at present. Or to put it the other way, in order to obliterate the Alpine lakes and restore the slopes of the valleys to what, if this hypothesis were true, must have been their original inclination, the Alps would need to be pushed up until they attained twice their present elevation. Now, we are hardly prepared to admit that the Swiss mountains were 30,000 feet high before the glacial period. If our Alpine and Northern lake-basins cannot be attributed to movements of depression, still less can they be accounted for by any system of fractures;—they lie neither in gaping cracks nor on the down-throw sides of dislocations. In a word, a study of the structure, inclination, and distribution of the rock-masses in which our lake-basins appear throws no light upon the origin of those hollows. We probably find in many cases that the position and form of a basin have been influenced in some way by the character of the rocks in which it lies—but we detect no evidence in the rock-masses themselves to account for its production. It is not necessary, however, that I should on this occasion mention each and every cause which has been suggested for the origin of rock-bound hollows. Some of these suggestions are unquestionably well founded. For example, there can be no doubt that certain lakes have been produced by the sudden damming-up of a valley in consequence of a fall of rock from adjoining slopes or cliffs; others, again, occupy holes caused by the falling in of the roofs of caves and subterranean tunnels; while yet others have been formed by a current of lava flowing across a valley and thus ponding back its stream, just as many a temporary sheet of water has been brought into existence in a similar way by the abnormal advance of a glacier. In these and other ways lakes have doubtless originated again and again, but the causes just referred to are all more or less exceptional, and manifestly incapable of producing the phenomena so conspicuous in the lake-regions of Britain, Scandinavia, and the Alps.

Ramsay, to whom the varied phenomena of glacier-regions had been long familiar, was struck by the remarkable fact that fresh-water lakes predominate in Northern and Alpine countries, while they are comparatively rare in regions further south and outside of mountainous districts. The great development of lakes in Finland finds no counterpart in the low grounds of southern latitudes. It is in regions where glacial action formerly prevailed that rock-basins are most numerous, and this suggested to Ramsay that in some way or other the lakes of the Alps and the North were connected with glaciation. The final solution of the problem flashed upon him while he was studying the glacial features of Switzerland. His scientific imagination enabled him to reproduce in his own mind the aspect presented by the Alps during the glacial period, when the great mountain-valleys were choked with glacier-ice, which flowed out upon the low grounds of Germany, France, and Northern Italy, so as to cover all the sites of the present lakes. He saw that under such conditions enormous erosion must have been effected by the ice, by means of the rocky rubbish which it dragged on underneath, and that this erosion, other things being equal, would be most intense where the ice was thickest and the ground over which it advanced had the gentlest inclination. Such conditions, he inferred, would be met with somewhere in the lower course of a valley between the steeper descent of its upper reaches and the

<sup>1</sup> The Inaugural Lecture at the opening of the Class of Geology and Mineralogy in the University of Edinburgh, October 27, 1882, by James Geikie, LL.D., F.R.S. L. and E., Regius Professor of Geology and Mineralogy in the University. Continued from p. 46.

termination of the glacier. This inference was suggested by the consideration that pressure and erosion would be least when the glacier was flowing upon a steep slope, while at the base of such a slope where the valley flattened out, the ice would tend to heap up, as it were, and produce the maximum amount of pressure and erosion. Thereafter, as the ice continued to flow down its valley, it would become thinner and thinner until it reached its termination—and pressure and erosion would diminish with the gradual attenuation of the glacier. Such conditions, after some time, would necessarily result in the formation of elongated rock-basins, sloping in gradually from either end, and attaining their greatest depth at some point above a line drawn midway between the upper and lower ends of a hollow. There are many other details connected with this most ingenious theory which I cannot touch upon at present. It will be sufficient to say that the observed facts receive from it a simple and satisfactory explanation. Like all other well-based theories, it has been fruitful in accounting for many other phenomena, a study of which has developed it in various directions, and enabled us to understand certain appearances which the theory as at first propounded seemed hardly adequate to explain. As a proof of the soundness of Ramsay's conclusion that ice is capable of excavating large rock-basins, I may mention that his theory has led to the prediction of facts which were not previously known to geologists. He had pointed to the occurrence, in many of the sea-lochs of Western Scotland, of deep rock-bound hollows, which he concluded must have been formed by great valley-glaciers in the same way as the hollows occupied by fresh-water lakes in this and other similarly glaciated countries. Some years later, having discovered that the Outer Hebrides had been glaciated across from side to side by a *mer de glace* flowing outwards from the mainland, and having been satisfied as to the truth of the glacial-erosion theory, I was led by it to suppose that deep rock-basins ought to occur upon the floor of the sea along the inner margin of most of our Western Islands. This expectation was suggested by the simple consideration that those islands, presenting, as they for the most part do, a steep and abrupt face to the mainland, must have formed powerful obstructions to the out-flow of the *mer de glace* in the direction of the Atlantic. This being so, great erosion, I inferred, must have ensued in front of those islands. The lower part of the *mer de glace* which overflowed them would be forced down upon the bed of the sea by the ice continually advancing from behind, and compelled to flow as an under-current along the inner margin of the islands, until it circumvented the obstruction, and resumed the same direction as the upper portion of the *mer de glace*. A subsequent careful examination of the Admiralty's Charts of our western seas, which afford a graphic delineation of the configuration of the sea-bottom, proved that the deduction from Ramsay's theory was perfectly correct. Were that sea bed to be elevated for a few hundred feet, so as to run off the water, and unite the islands to themselves and the mainland, we should find the surface of the new-born land plentifully diversified with lakes—all occupying the positions which a study of the glaciation of the mainland and islands would have led us to expect. Among the most considerable would be a chain of deep lakes extending along the inner margin of the Outer Hebrides, while many similar sheets of water would appear in front of those islands of the Inner Group that face the deep fiords of our western shores.

The few examples now given of geological methods of inquiry may suffice to show that the process of reading and interpreting the past in the light of the present necessitates not only accurate observation, but an extensive acquaintance with the mode in which the operations of Nature are carried on. They also serve to show that just as our knowledge of the past increases, so our insight into the present becomes more and more extended. For if it be true that the present is the key to the past, it is not less certain that without that unfolding of the past which a study of the rocks has enabled us to accomplish, we should not only miss the meaning of much that we see going on around us, but we should also remain in nearly complete ignorance of all that is taking place within the crust of our globe. Thus, although our science may be correctly defined as an inquiry into the development of the earth's crust and of the faunas and floras which have successively clothed and peopled its surface—yet that definition is somewhat incomplete. For, as we have seen, this inquiry into the past helps us to understand existing conditions better than we should otherwise do. In this respect it is with geology as with human history. The philosophical historian

seeks in the past to discover the germ of the present. He tells us that we cannot hope to understand the complicated structure and relations of a society like ours without a full appreciation of all that has gone before. And so it is in the case of geological history. The present has grown out of the past, and bears myriad marks of its origin, which would either be unobserved or remain totally meaningless to us, were the past a sealed book. No student of physical geography, or of zoology and botany, therefore can afford to neglect the study of geology, if his desire be to acquire a philosophical comprehension of the bearings of those sciences. For it is geology which reveals to us the birth and evolution of our lands and seas—which enables us to follow the succession of life upon the globe, and to supply many of the missing links in that chain, which, as we believe, unites the beginning of life in the far distant past with its latest and highest expression in man. By its aid we track out the many wanderings of living genera and species which have resulted in the present distribution of plants and animals. But for geology, indeed, that distribution would be for the most part inexplicable. How, for example, could we account for the often widely separated colonies of arctic-alpine plants which occur upon the mountains of Middle and Southern Europe? How could these plants possibly have been transferred from their head-quarters in the far north to the hills of Britain, and Middle Germany, to the Alps and the Pyrenees? Not the most prolonged and laborious study of the botanist could ever have solved the problem. But we learn from the geologist that the apparent anomalous distribution of the flora in question is quite what his study of the rocks would have led him to expect. He now, indeed, appeals to the occurrence of those curious colonies of arctic-alpine plants as an additional proof in support of his view that during a comparatively recent period our continent experienced a climate of more than arctic severity. He tells us that at that time the reindeer, the glutton, the arctic fox, the musk ox, and other arctic animals migrated south into France, while a Scandinavian flora clothed the low grounds of Middle Europe. By and by, when the arctic rigour of the climate began to give way, the northern species of plants and animals slowly returned to the high latitudes from which they had been driven. Many plants, however, would meet with similar conditions by ascending the various mountains that lay in the path of retreat, and there they would continue to flourish long after every trace of an arctic-alpine flora had vanished from the low ground. This explanation fully meets the requirements of the case. It leaves none of the facts unaccounted for, but is in perfect harmony with all. But as if to make assurance doubly sure, Dr. Nathorst, a well-known Swedish geologist, recently made a search in the low grounds of Europe for the remains of the arctic-alpine flora, and succeeded in discovering these in many places. He detected leaves of the arctic willow and several other characteristic northern species in the glacial and post-glacial deposits of Southern Sweden, Denmark, England, Germany, and Switzerland, and thus supplied the one link which might have been sidered necessary to complete a chain of evidence already almost perfect.

From this and many similar instance that might be given we learn that the reconstruction of the past out of its own ruins is not mere guess-work and hypothesis. The geologist cannot only demonstrate that certain events have taken place, but he can assure us of the order in which they succeeded one after the other, during ages incalculably more remote than any with which historians have to deal. The written records out of which are constructed the early history of a people cannot always be depended upon—allowance must be made for the influences that may have swayed the chroniclers, and these are either unknown or can only be guessed at. It follows therefore that events are seldom presented to us in a consecutive history exactly as they occurred. They are always more or less coloured, and that colouring often depends fully as much upon the idiosyncrasies of the modern compiler as upon those of the contemporaneous recorder. The geologist has at least this advantage over the investigator of human history, that his records, however fragmentary they may be, tell nothing more and nothing less than the truth. Any errors that arise must be due either to insufficient observation or bad reasoning, or to both, while the progress of research and the penetrating criticism which every novel view undergoes must sooner or later discover where the truth lies. In this way the history of our globe is being gradually reconstructed—to an extent, indeed, that the earlier cultivators of the science could not have believed possible. But although



many blanks in the records have been filled up, and our knowledge will doubtless be yet greatly increased, it must nevertheless be admitted that this knowledge must always bear but a very small proportion to our ignorance. In this, however, there is nothing to discourage us, as we may be quite sure that the work remaining to be done will far exceed all the energies of many generations to accomplish.

It is sometimes objected to Geology that its results are not always so exact as those which are obtained by an experimental science like chemistry. We are reproached with the fact that our theoretical conceptions undergo frequent modification, and are even often abandoned, to be succeeded by others which, after flourishing for a time, are in like manner overturned and thrown aside. But the same reproach, if it be one, might be brought against other sciences. Each advancing science has its problems and speculations. And we cannot often feel assured that the solution now given of those problems will in all cases stand the test of time. Our theoretical conceptions of the ultimate constitution of matter, for example, have within comparatively few years undergone considerable change, and yet no one values chemistry the less. Let our theories be what they may, they do not and cannot overturn the results obtained by verified observation and often repeated and varied experiment. It remains for ever true that water is composed of oxygen and hydrogen, let our views of the atomic theory change as they may. And so it is not less certain that strata of conglomerate and sandstone containing marine or fresh-water fossils are of aqueous origin, however much our theoretical conceptions may vary as to the uniformity in degree between the past and present operations of Nature. It is true we did not see the conglomerate and sandstone in process of formation, but we know by observation that these rocks exactly resemble deposits of gravel and sand which are now being accumulated in water. Nature in this case makes the experiment for us, whereas the chemist has to do this for himself. The latter, having well ascertained by varied experiments the composition of certain samples of water, henceforth concludes that all water is made up of the same two gases in definite proportions. But this conclusion of his is just as much an assumption as the inference of the geologist that strata containing marine or freshwater fossils are aqueous accumulations. It is when we come to the larger generalisations of our science that we are more likely to go astray. The problems we have to solve demand not only an accurate knowledge of widely scattered phenomena, but a ready command of logical analysis. The facts may be sufficiently abundant, but if we reason badly we of course miss their meaning. Or, on the other hand, the evidence may be more or less imperfect. There are blanks which we fill up with conjecture—which can do no harm so long as we do not treat our conjectures as if they were facts. But when the gaps in the evidence are numerous, each theoriser will fill them up after his own fashion, and very various results will thus be obtained. Even in cases of this kind, however, a rigorous application of logical analysis will enable us to detect the fallacies which may underlie all the competing theories; and we are thus prepared to frame a new explanation for ourselves, and to set about searching for additional facts to prove or disprove our notions. In all such investigations it is obviously the duty of a careful observer and theoriser to see well to his premises—to be absolutely sure as to his facts, and to distinguish clearly between what is substantial knowledge, and what is mere conjecture. He will thus be in a position to judge whether his conclusions are based on a solid foundation or not. In a science of observation like geology, theory is necessarily often in advance of the facts. Some, indeed, have insisted that all conjectural explanations are quite a mistake; that it would be better to avoid theorising altogether, and to wait patiently until the chain of evidence had completed itself. I am afraid that, were it possible to follow this advice, we might often have to wait a very long time. After all, a heap of bricks is only a potential house: it will not grow up into walls without the aid of architect and builder. Discoveries in science have no doubt been made occasionally by isolated and haphazard observations; but that is exceptional, and we should not be where we are now had the examination of Nature been always conducted after such a fashion. If additional evidence be required, we must first have some notion where to look for it. In other words, it is essential to progress that we should have preconceived opinions or theories, which enable us to arrange the facts we already possess, and to point out the directions in which further evidence may be looked for. We cannot be too careful, however, that

our preconceived notions do not lead us to colour the evidence or to blind us to facts that tell against our views. Every theory should be considered provisional until its truth has been fully demonstrated by an overwhelming array of testimony in its favour. Until this consummation is arrived at we must be constantly testing its truth, and be ready to abandon it at once whenever the evidence shows it to be erroneous. The failure of one theory after another need not disconcert or discourage us; for each failure, by reducing the number of possible explanations, must necessarily bring us nearer to our goal—the truth. I cannot but deem it a strong point in favour of geology as a branch of education that it not only cultivates the faculty of clear and continuous observation, but abounds in unsolved problems which are ever suggesting new ideas and thus stimulating that imagination which is one of the noblest gifts of our race. It is no reproach that the progress of our science is marked by the modification and abandonment of numerous hypotheses and theories. On the contrary, these afford a measure of the rate at which geology advances—just as this last yields the strongest testimony to the good results that accrue from having some provisional view by which to direct the course of our observations.

It is unavoidable that in the onward march of a science the facts become at last so numerous as to task all the energies of its votaries to keep abreast of their time. When a beginner first surveys the wide field embraced by geological inquiry, he may not unnaturally experience a feeling akin to despair. How is it possible, he may think, that I can master all these manifold details—how can I test the truth of all those numerous inferences and conclusions—and yet have sufficient leisure and energy left to undertake original observation? Well, no one can hope to advance the science in all its departments. When we reflect that in order to obtain a complete comprehension and mastery of the existing condition of things we should require to be adepts in physics, mechanics, chemistry, and every branch of natural science, it is obvious that such a perfect knowledge is beyond attainment. It is needless, therefore, that we should strive to become “admirable Crichtons” in this nineteenth century, and no beginner need be discouraged by the greatness of the science which he desires to cultivate. It is only by division of labour that so much has been accomplished; and the results are now so systematised that it is quite possible for any intelligent inquirer to gain a thorough comprehension of the principles of the science. But this it is absolutely necessary to acquire, and the student, therefore, should at first devote all his energies to learn as much as he can of those principles and their application. When he has progressed so far, he is then ready to set out as an explorer in the well-assured hope that if he be true to the logical methods which have hitherto succeeded so well, he will not fail to reap his reward in the discovery of new truths. But to secure success we must be content to be specialists. In other words, we must concentrate our energies upon some particular lines of inquiry, and do our utmost to work these out in all their details. At the same time we should make a great mistake if we did not always keep in mind the broader bearings of our science, and endeavour to maintain as wide a knowledge as we can of all its branches. Each of these, we may be sure, has something to tell which will aid us in our own special inquiries. We cannot, therefore, afford to neglect the side-lights which are thrown upon our path from the lamps of others who are working in adjacent fields. One cannot help thinking that many specialists would have given us more and better work if they had not allowed themselves to be cramped and narrowed by continuing too long in one rut or groove. They dig so deep that they get into a hole out of which it is sometimes difficult to climb, and thus not infrequently the work being done by fellow-labourers, escapes them, and they miss the suggestions which a knowledge of that work might otherwise have yielded them.

I have said nothing as to the practical applications of our science—that branch of our subject which is termed economic geology—not because I consider it the less important, but because its value is generally recognised and need not now be insisted upon. Many, I do not doubt, enter upon their geological studies with a distinct view of obtaining from the science such help as it can afford them in the practical pursuits of life. To such inquirers it will be my pleasure not less than my duty to give every assistance that is in my power. But I would point out to them that there is no short cut to the attainment of the knowledge they are in quest of. The study

of economic geology cannot be separated from that of the recognised principles and methods of inquiry which must be followed by the scientific investigator. On the contrary, the more thoroughly we devote ourselves to the prosecution of geology for its own sake the better able shall we be to appreciate its economic bearings.

In beginning the duties of this Chair, if I enjoy certain advantages over my predecessor, I also at the same time labour under considerable disadvantages. The Class Museum formed by him, and the other appliances and aids to teaching which he laboriously gathered together have been generously handed over to the Chair—and this, I need not say, has greatly smoothed my path. But, on the other hand, he has left behind him a reputation which must bear hard upon me. He has not only sustained but increased the fame of what has been termed the Scottish School of Geology, and I feel that it will task all my energies to emulate the high standard he maintained as a teacher. It is not without diffidence, therefore, that I commence this course; but my hope is that the love of science, which has hitherto carried me over many years of a laborious occupation, may at least succeed in warming and sustaining the enthusiasm of those who come here to study with me what geology has to reveal concerning the past and present.

### A METHOD FOR OBSERVING ARTIFICIAL TRANSITS<sup>1</sup>

AS many astronomers who intend to observe the coming transit of Venus have neither the time nor means for making the necessary arrangements to practice on artificial transits, the simple method here proposed may be advantageously employed. Instead of observing an artificial sun and planet placed at a distance of several thousand feet from the observer, I would suggest that the real sun be observed, and the planet Venus to be represented by a circular disk, held, in the common focus of the objective and eye-piece, by means of a narrow metallic arm fastened to the eye-piece.

The relative motion of the sun and Venus can then be produced by so adjusting the rate of the driving-clock that the angular motion of the telescope on the hour-axis shall exceed the diurnal motion of the sun by seventeen seconds of time per hour. In this way, as the atmospheric disturbances of the sun's limb are real, a near approach to the phenomena observed during an actual transit will result. If a light-shade glass is employed, the opaque disk will be seen before it comes into apparent contact with the sun. The observer can, however, by an exercise of the will, confine his whole attention to the sun's limb.

By using a heavier shade-glass the disk will not be seen until it is projected against the image of the sun. The angular diameter of Venus at the time of transit being about  $65''$ , the diameter of the opaque disk should be  $65'' \cdot \sin 1'' = 0.00031''$ ,  $1''$  being the focal length of the telescope used. The position angle of the point of contact can be changed at will by simply moving the telescope in declination.

### ELECTRIC LIGHTING, THE TRANSMISSION OF FORCE BY ELECTRICITY<sup>2</sup>

HAVING received the honour of being elected Chairman of the Council of the Society of Arts for the ensuing year, the duty devolves upon me of opening the coming Session with some introductory remarks. Only a few months have elapsed since I was called upon to deliver a presidential address to the British Association at Southampton, and it may be reasonably supposed that I then exhausted my stock of accumulated thought and observation regarding the present development of science, both abstract and applied; that, in fact, I come before you, to use a popular phrase, pretty well pumped dry. And yet so large is the field of modern science and industry, that, notwithstanding the good opportunity given me at Southampton, I could there do only scanty justice to comparatively few of the branches of modern progress, and had to curtail, or entirely omit, reference to others, upon which I should otherwise have wished to dwell. There is this essential difference between the British Association and the Society of Arts, that the former can only take an annual survey of the progress of science, and must then confide to indi-

viduals, or to committee, specific inquiries, to be reported upon to the different sections at subsequent meetings; whereas the Society of Arts, with its 3,450 permanent members, its ninety-five associated societies, spread throughout the length and breadth of the country, its permanent building, its well-conducted *Journal*, its almost daily meetings and lectures, extending over six months of the year, possesses exceptionally favourable opportunities of following up questions of industrial progress to the point of their practical accomplishment. In glancing back upon its history during the 128 years of its existence, we discover that the Society of Arts was the first institution to introduce science into the industrial arts; it was through the Society of Arts and its illustrious Past President, the late Prince Consort, that the first Universal Exhibition was proposed, and brought to a successful issue in 1851; and it is due to the same Society, supported on all important occasions by its actual President, the Prince of Wales, that so many important changes in our educational and industrial institutions have been inaugurated, too numerous to be referred to specifically on the present occasion.

Amongst the practical questions that now chiefly occupy public attention are those of Electric Lighting, and of the transmission of force by electricity. These together form a subject which has occupied my attention and that of my brothers for a great number of years, and upon which I may consequently be expected to dwell on the present occasion, considering that at Southampton I could deal only with some purely scientific considerations involved in this important subject. I need hardly remind you that electric lighting, viewed as a physical experiment, has been known to us since the early part of the present century, and that many attempts have, from time to time, been made to promote its application. Two principal difficulties have stood in the way of its practical introduction, viz., the great cost of producing an electric current so long as chemical means had to be resorted to, and the mechanical difficulty of constructing electric lamps capable of sustaining, with steadiness, prolonged effects. The dynamo-machine, which enables us to convert mechanical into electrical force, purely and simply, has very effectually disposed of the former difficulty, inasmuch as a properly conceived and well constructed machine of this character converts more than ninety per cent. of the mechanical force imparted to it into electricity, ninety per cent. again of which may be re-converted into mechanical force at a moderate distance. The margin of loss, therefore, does not exceed twenty per cent., excluding purely mechanical losses, and this is quite capable of being further reduced to some extent by improved modes of construction; but it results from these figures that no great step in advance can be looked for in this direction. The dynamo-machine presents the great advantage of simplicity over steam or other power-transmitting engines; it has but one working part, namely, a shaft which, revolving in a pair of bearings, carries a coil or coils of wire admitting of perfect balancing. Frictional resistance is thus reduced to an absolute minimum, and no allowance has to be made for loss by condensation, or badly fitting pistons, stuffing boxes, or valves, or for the jerking action due to oscillating weights. The materials composing the machine, namely, soft iron and copper wire, undergo no deterioration or change by continuous working, and the depreciation of value is therefore a minimum, except where currents of exceptionally high potential are used, which appear to render the copper wire brittle.

The essential points to be attended to in the conception of the dynamo-machine, are the prevention of induced currents in the iron, and the placing of the wire in such position as to make the whole of it effective for the production of outward current. These principles, which have been clearly established by the labours of comparative few workers in applied science, admit of being carried out in an almost infinite variety of constructive forms, for each of which may be claimed some real or imaginary merits regarding questions of convenience or cost of production.

For many years after the principles involved in the construction of dynamo-machines had been made known, little general interest was manifested in their favour, and few were the forms of construction offered for public use. The essential features involved in the dynamo-machine, the Siemens armature (1856), the Pacinotti ring (1861), and the self-exciting principle (1867), were published by their authors for the pure scientific interest attached to them, without being made subject matter of letters patent, which circumstance appears to have had the contrary effect of what might have been expected, in that it has retarded the introduction of this class of electrical machine, because no person or firm had a sufficient commercial interest to undertake

<sup>1</sup> By Prof. J. M. Schaeberle, Ann Arbor, Michigan. From the *American Journal of Science*.

<sup>2</sup> Address by Dr. C. W. Siemens, F.R.S., Chairman of the Society of Arts, November 15.